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Observation of two-magnon bound states in the spin 1/2 ladders of $\mathbf{La_{14-x}Ca_xCu_{24}O_{41}}$

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Phonon-assisted two-magnon absorption is studied in the spin 1/2 two-leg ladders of $La_{14-x}Ca_xCu_{24}O_{41}$ (x=9 and 10). We present optical conductivity data for $E \parallel c$ (legs) and $E \parallel a$ (rungs) between $T = 4$ K and 500 K. Three prominent features are observed: Two peaks at about 2150 and 2800 cm^{-1} reflect maxima in the density of states of the strongly dispersing two-magnon singlet bound state, and a broad peak at $\approx$ 4000 cm^{-1} is identified with the two-magnon continuum. Two different theoretical approaches are presented, namely Jordan-Wigner fermions and an optimized perturbation expansion using the flow equation method. Both describe the data very well. We find exchange constants of $J_\parallel \approx J_\perp \approx 1050$ cm^{-1} and exclude the often proposed ratio $J_\perp/J_\parallel \approx 1/2$. Calculations studying the influence of a finite ring exchange are under progress. We find an intriguing similarity between the high-energy magnetic absorption of the undoped 2D cuprates and the two-magnon continuum of the ladders, which supports the interpretation of the former in terms of strong quantum fluctuations and confirms the failure of spin-wave theory to describe the high-energy short-wavelength excitations of the 2D cuprates.